

GENERAL AVIATION INSPECTION TRAINING SYSTEM (GAITS)

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This research demonstrates how advanced technology can be used for inspection training to reduce inspector errors in the General Aviation maintenance environment. It extends work from the past several years to a functional prototype computer-based training system, the General Aviation Inspection Training System (GAITS), consisting of the four modules of introduction, training, simulation, and design and analysis. The specific activities conducted in support of the development of GAITS included the following: (1) the development and evaluation of alternate interfaces, (2) the development of scripts and storyboards, with the scripts specifying the text, the computer-based graphics, the simulations, and the audio content to be used, and the storyboards depicting individual frames showing the specific content of the scripts for a single module, (3) the computer coding of the individual modules, and (4) the testing of the modules. This report provides a brief description of the development effort followed by an overall description of the tool.

INTRODUCTION

Aircraft inspection and maintenance is a complex system with many interrelated human and machine components. The linchpin of this system, however, is the human, who is fallible, despite the training mandated by the US federal government and the Federal Aviation Administration (FAA). In the General Aviation (GA) environment, the complexity of this system is further compounded by the variety of geographically dispersed entities, including repair and maintenance facilities situated at different locations, large international carriers, regional and commuter airlines, as well as the fixed-based operators associated with this domain. As a result of its inherently intricate nature, continuing emphasis must be placed on developing interventions to make the inspection and maintenance system more reliable and/or more error tolerant. Recognizing the importance of this to public safety, the FAA, under the auspices of the National Plan for Aviation Human Factors [1, 2], has pursued human factors research, primarily focusing

on the Aircraft Maintenance Technician (AMT).

Unfortunately, the GA segment, which constitutes a considerable portion of the nation's aviation system, is frequently not considered in this research. Since its reliability is crucial if we are to ensure the safety of the overall air transportation system, the lack of GA research is a significant concern. Furthermore, the GA inspection process, which is responsible for identifying and fixing aircraft defects, plays a key role in the maintenance system. As research has found, adhering to inspection procedures and protocols is relatively easy; however, the monitoring and tracking of the efficacy of these procedures is not. To address this issue, task analyses of aircraft inspection operations at geographically dispersed GA facilities operating under the Federal Aviation Regulation (FAR) Parts 91, 135, and 145 were conducted. The recommendations based on these analyses were then used to develop the General Aviation Inspection Training System (GAITS), a computer-based inspection training program focused on improving

inspector performance. The motivation for its development, as well as its precursors, grew out of previous and current approaches to training.

NEED FOR COMPUTER-BASED INSPECTION TRAINING

Existing training for inspectors in the aircraft maintenance environment tends to be primarily on-the-job. Nevertheless, this may not be the best method of instruction [1] because, for example, feedback may be infrequent, unmethodical, and/or delayed. Moreover, in certain instances feedback is economically prohibitive or not feasible due to the nature of the task. Even more significantly, although such training for improving visual inspection skills of aircraft inspectors has been shown to improve the performance of both novice and experienced inspectors [3, 4, and 5], it is frequently lacking at aircraft repair centers and aircraft maintenance facilities [6]. Current research, however, indicates that training using representative photographic images showing a wide range of conditions can effectively be used to teach visual inspection skills, in part because this approach provides immediate feedback on the trainee decisions [6]. The use of these realistic photographic images, as supported by trainee feedback, has been shown to be superior to OJT training alone [5, 7].

These findings, coupled with the many constraints and requirements imposed by the aircraft maintenance environment, suggest that one of the most viable approaches for delivering inspector training is through Computer-Based Training (CBT), and, in fact, this method does offer several advantages over traditional training protocols: It is more efficient, it facilitates standardization, and it supports distance learning. Specifically in the domain of visual inspection, the use of computers for off-line inspection training has shown

significant inspection performance improvement in a laboratory environment [8, 9, and 10]. Even though many training delivery systems, such as computer-aided instruction, computer-based, multi-media training, and intelligent tutoring systems, are currently being used, most of the applications of computer technology in training have been restricted to complex diagnostic tasks in the defense/aviation industry. Extending this computer-based training to inspection tasks resulted in the Automated System of Self Instruction for Specialized Training (ASSIST) [11], developed for commercial aviation in cooperation with Lockheed Martin Aircraft Center and Delta Air Lines. This research has now been extended to the GA sector through the development of the prototype training system, GAITS.

METHODOLOGY

The research for GAITS followed a structured methodology comprised of an analysis of visual inspection practices in GA, a task analysis of current GA inspection training procedures, the development and organization of inspection training materials, and the development of a prototype training system.

Analysis of visual inspection practices in GA

In the first step, the research team was formed, and a literature review was conducted. In addition, preliminary visits to GA facilities were made to outline the scope of the effort. The team visited sites with both light and heavy inspection and maintenance work governed by FAR Parts 91, 135, and 145. The GA partners, located at geographically dispersed maintenance sites, provided the research team with access to their facilities, personnel, and documentation, allowing the team to analyze their existing inspection protocols at

different times of the shift. In this process, the research team worked with the managers, line supervisor/shift foremen, and aircraft maintenance technicians and inspectors. Data was obtained through a variety of techniques, including observation, shadowing, structured and unstructured interviews, appropriate verbal protocol analysis tools, and the analysis of company-wide procedures, documentation, and manuals.

Task analysis

A detailed task analysis [12, 13] of the inspection process was then conducted to determine the knowledge, skills, and abilities necessary for its performance. From this analysis, the behavioral objectives of the training program were identified, forming the basis for the evaluation of the training program. The researchers conducted follow-up interviews as needed with the various personnel involved to ensure that all aspects of the inspection process were covered, discussing any remaining issues concerning the tasks.

Development and organization of material

Based on this research, the following six stages in the inspection process were defined: initiate, access, search, decision, respond and return, each having various inspection functions. Using an error taxonomic approach, the inspection tasks were analyzed, resulting in a list of possible errors and the correct outcomes. Following this analysis, a comprehensive error classification scheme was developed by expanding each step of the inspection process into sub-steps and then listing the possible failures for each using the Failure Modes and Effects Analysis (FMEA) approach. Next, a classification scheme for errors was developed based on Rouse and Rouse's Human Error Classification Scheme

[14], a framework classifying human errors based on causes as well as contributing factors and events. This scheme has been employed to record and analyze human errors in such contexts as detection and diagnostics, and trouble-shooting of aircraft mission flights. For all inspection functions, the possible errors were listed and mapped using this error taxonomy to identify the error genotypes. Based on this information, expert human factors knowledge was applied to the sub-tasks to identify specific interventions (e.g., providing job-aids), to minimize the negative effects due to specific error shaping- factors and to improve performance. Then, training needs were developed to produce the correct outcome.

Development of the prototype training system

Following the identification and organization of the inspection material, an initial prototype of the system was developed based on the activities described below.

Content: This activity outlined aircraft inspection training, organizing it using the feedback from the task analysis.

Method: This activity incorporated into GAITS the training methods that have been used effectively for inspection training [15]: pre-training, feedback, active training, progressive parts training, schema training and feedforward training.

Delivery system: This activity evaluated different potential solutions, identifying technical and

functional specifications for the training delivery system.

Development of the interface: This activity focused on developing and evaluating alternate screen designs. The interfaces, which had the "look and feel" of the final system, included such elements as screen layout, icons, and buttons. The prototypes, which focused on ease-of-use and simplicity in the presentation of information in addition to emphasizing human factors principles of interface design, were revised iteratively based on the input obtained from user testing.

Development of scripts and storyboards: With the content and the interface design established, this activity focused on developing the production script. The script itself specified the text, the computer-based graphics, the simulations, and the audio content to be used. The storyboards depicted individual frames showing the specific content of the scripts for a single module.

THE GAITS SYSTEM

The specific system specifications and system structure of GAITS are detailed below.

System specifications

GAITS was developed using Macromedia Authorware 6.5, Macromedia Flash MX and Microsoft Access. The development work was carried out on a Pentium(R) 4, 2.4 GHz platform. The training program uses text, graphics, animation, video and audio, with the input entered using a keyboard and a mouse.

System Structure

GAITS consists of four modules: 1) Introduction 2) Training 3) Simulator and 4) Design and Analysis. The software combines graphical user interface technologies with good usability features. Users interact with the software through a

user-friendly interface employing a multimedia presentational approach. This interface, which is interactive and self-paced, combines text, audio, images and video.

Introduction Module

The Introduction Module, which provides information to the trainee about various facets of the program, consists of six units.

Inspection: This unit gives an overview of the CBT tool, introducing the trainee to different aspects of the software.

Types of inspection: This unit provides information about the various kinds of inspection found in the GA environment in addition to discussing different levels of visual inspection.



Figure 1: The Introduction Module demonstrates inspection procedures, such as a systematic search strategy

FAR's: This unit addresses the FAR's as they relate to GA procedures and guidelines.

Tools: This unit discusses the common tools used in GA inspection.

Factors: This unit describes the factors affecting visual inspection in GA.

Procedures: This unit discusses the procedure for GA inspection (Figure 1).

Training Module

The training module (Figure 2), which focuses on the visual inspection process, is divided into six units, each of which looks at one aspect of the inspection process.

Initiate: This unit begins the inspection process, with the inspector following validated guidelines using appropriate documentation to plan the inspection task appropriately.

Access: This unit discusses locating and accessing the area to be inspected.



Figure 2: The Training Module incorporates videos to demonstrate good practices

Search: This unit introduces scanning the inspection area for indications of defects using a good search strategy.

Decision: This unit discusses identifying the type of indication found in an inspection area, categorizing it by comparing it to a standard, and deciding the future course of action.

Respond: This unit covers the writing and issuing of a Non-Routine Repair Card.

Return: This unit emphasizes the importance of checking and returning equipment to its appropriate location.

The different units comprising this module help the trainee understand the conditions leading to error occurrences. In addition, they prescribe correct inspection procedures, detailing steps to prevent errors. To check trainee knowledge and understanding of this material, each concludes with a quiz.

Simulator Module

The Training Module teaches the trainee the proper procedure for inspection. To check this knowledge and provide the trainee with hands-on experience, the simulator provides a utility which simulates an aircraft wing and potential inspection conditions. The simulator module (Figure 3) provides tools (a flash light and a magnifying glass) for use in the simulated inspection. The trainee visually searches for defects and upon identification completes a Non-Routine Report Card. The trainee's performance is tracked in real time by the Design and Analysis Module.



Figure 3: The Simulator Module allows trainees to practice inspection and receive feedback on performance

Design and Analysis Module

The Design and Analysis Module provides the instructor with utilities for creating the questions in the Training Module and for tracking the performance of the trainee based on their answers. In addition, it allows for setting up the wing simulation environment (Figure 4) and for developing schemas by manipulating various task complexity factors. This capability can be used to assign scenarios to specific trainees.

The inspection performance of the trainee using the simulator is also tracked by this module.



Figure 4: The Design and Analysis Module allows trainers to customize scenarios for use in the Simulator Module

CONCLUSION

GAITS, a tool designed to help improve the inspection and decision-making performance of aircraft inspectors in the GA sector, was developed using a detailed and scientifically sound methodology. It embodies the following inherent anticipated that its use will lead to reduced errors and improved inspection quality in the GA environment.

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characteristics that can mitigate the shortcomings of OJT:

Completeness: GAITS will serve as a single source for GA inspection training.

Adaptability: GAITS can be customized, and, hence, the program can be tailored to accommodate individual differences in inspection abilities.

Efficiency: GAITS allows for intensive training, providing an efficient tool for improving inspection skills.

Integration: The system is designed to be an integrated training tool combining a variety of training methods.

Certification: With its automated record keeping, GAITS can be used as part of the certification process.

Instruction: GAITS can be integrated into the curriculum of FAA-certified A&P schools for training, giving student AMT's exposure to inspection material which they otherwise would not have access to.

GAITS will be made available to geographically disperse GA locations for testing and evaluation. It is

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